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Design optimisation of steel portal frames

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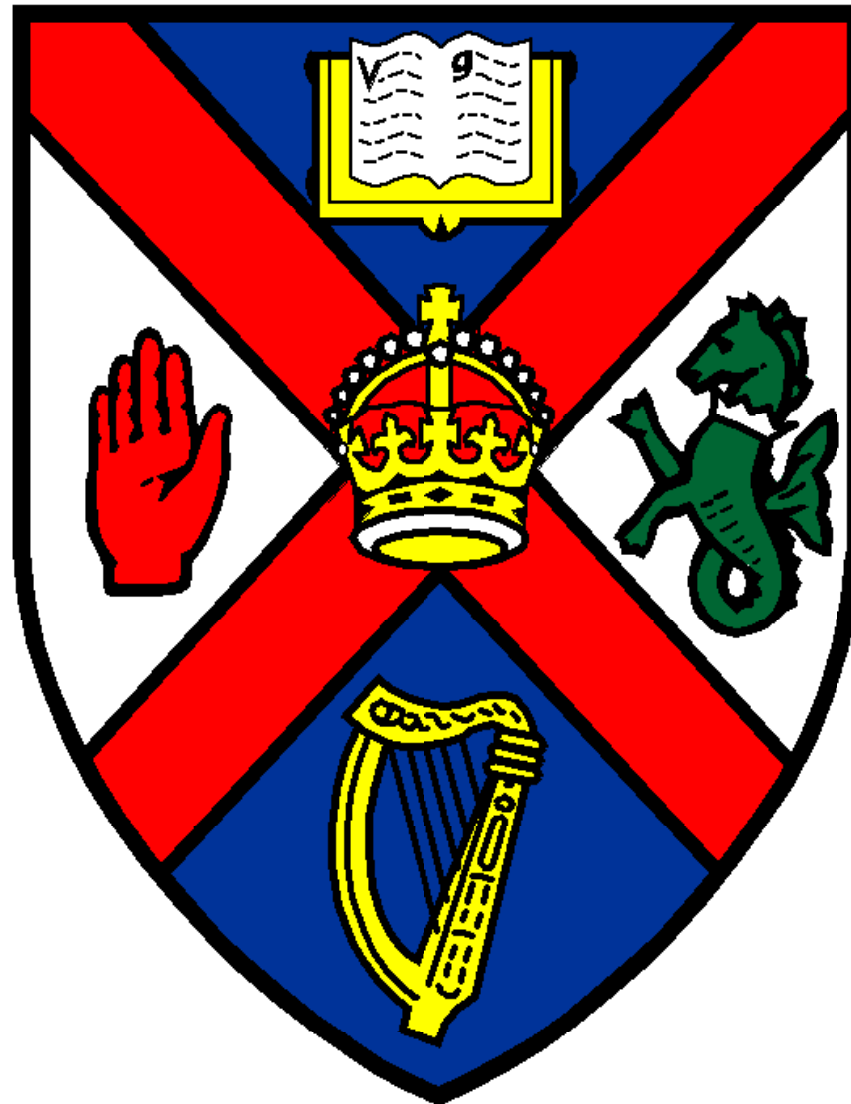
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Design optimisation of steel portal frames

Wei Sha

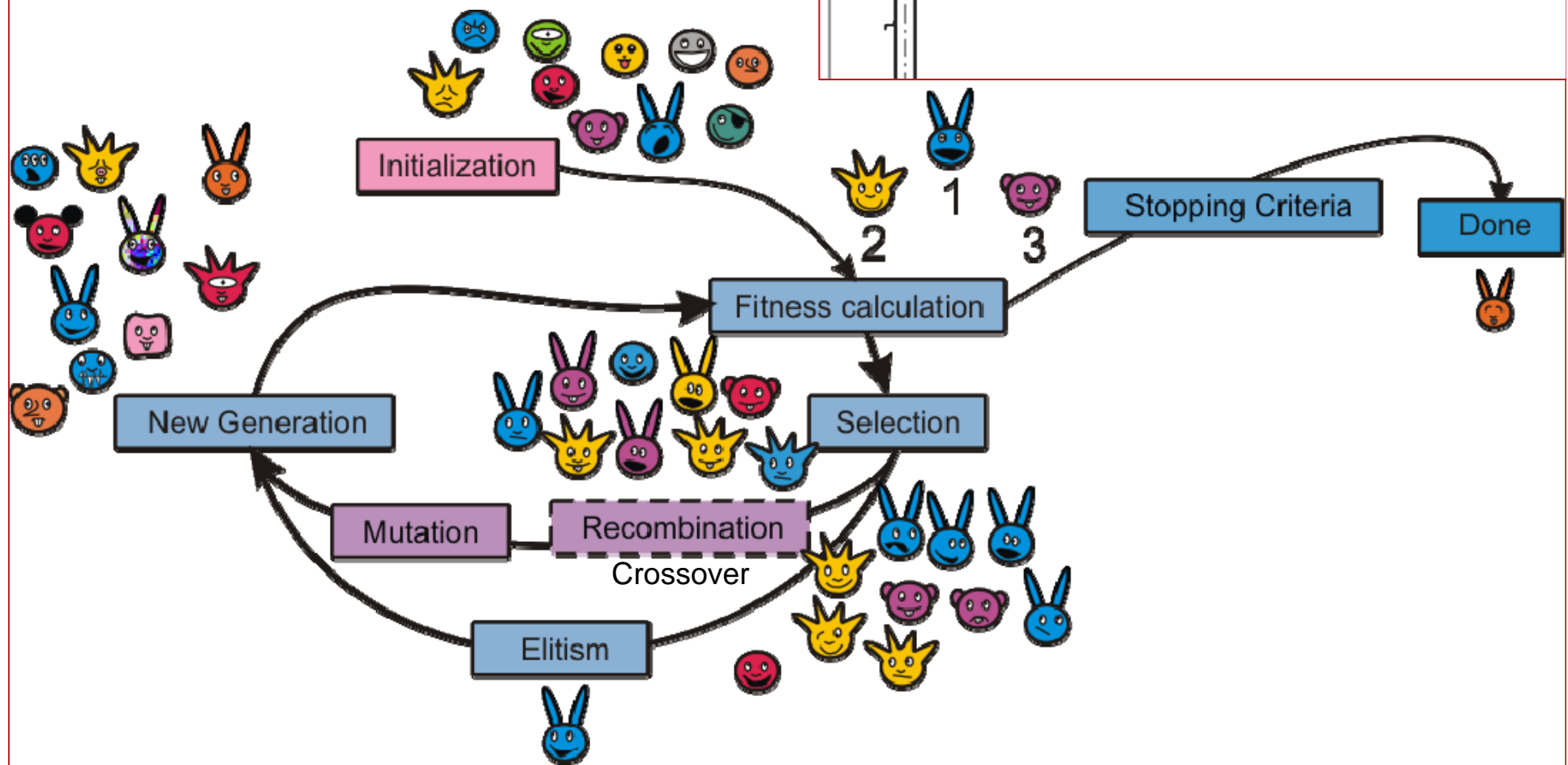
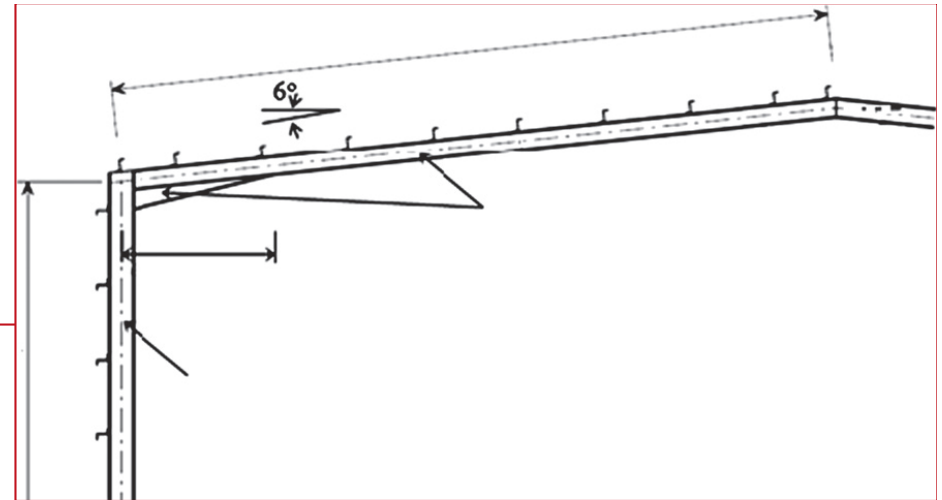
School of Planning, Architecture and Civil Engineering
Queen's University Belfast



Google Images “steel portal frame buildings uk”

column
rafter
purlins
side rails
cladding
eaves haunch
apex haunch

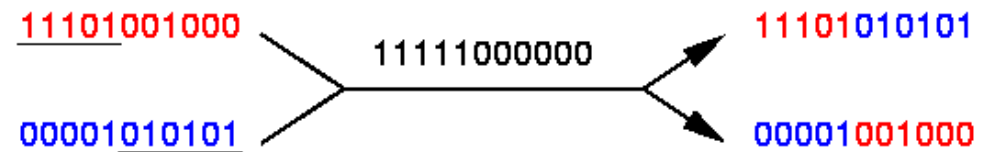
Genetic algorithm



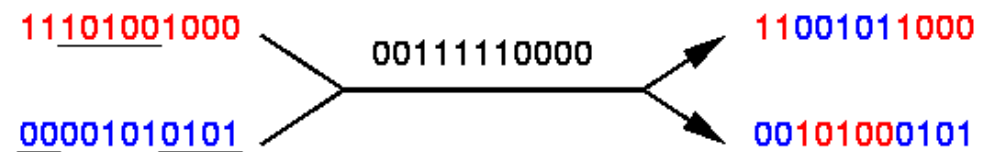
Journal of Constructional Steel Research, **86**, 2013, 74-84.

Initial strings Crossover Mask Offspring

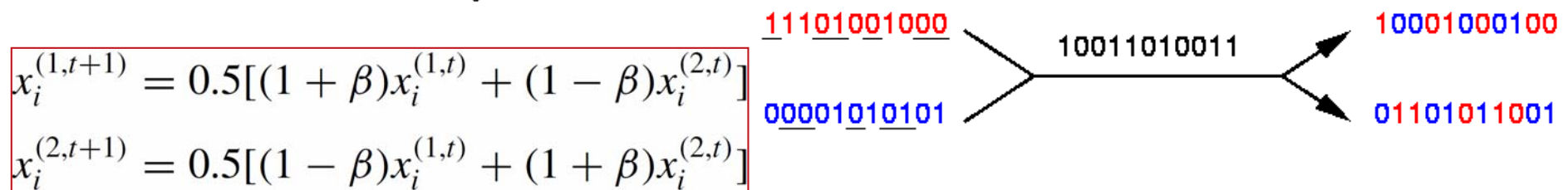
Single-point crossover:



Two-point crossover:



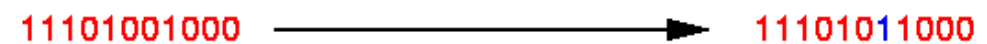
Uniform crossover:



$$x_i^{(1,t+1)} = 0.5[(1 + \beta)x_i^{(1,t)} + (1 - \beta)x_i^{(2,t)}]$$

$$x_i^{(2,t+1)} = 0.5[(1 - \beta)x_i^{(1,t)} + (1 + \beta)x_i^{(2,t)}]$$

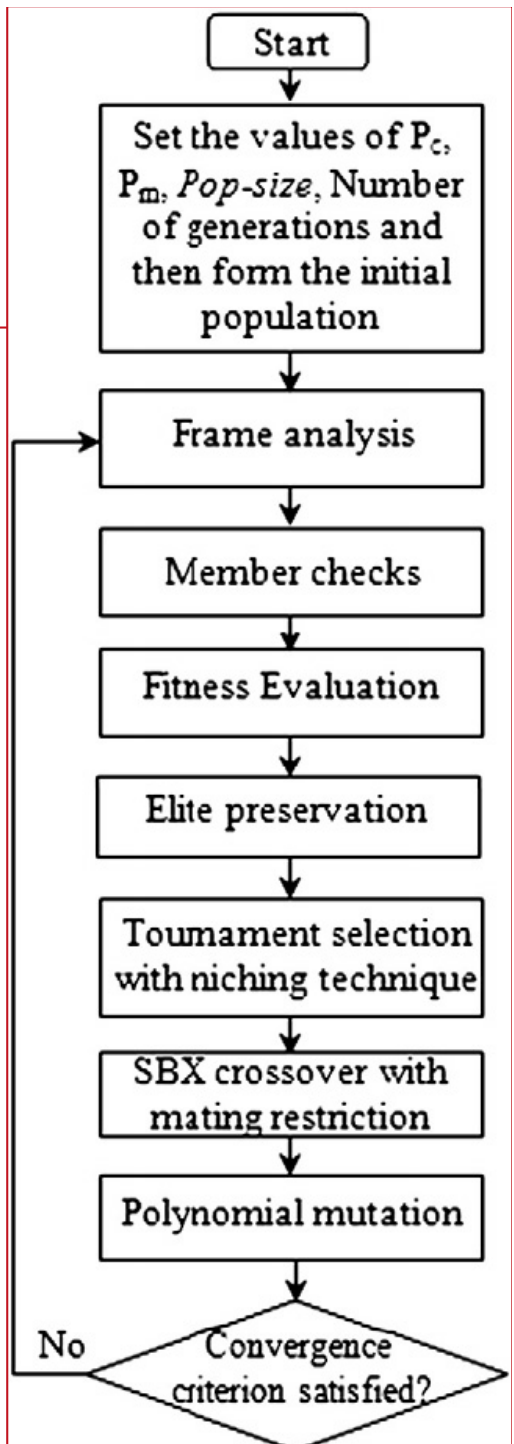
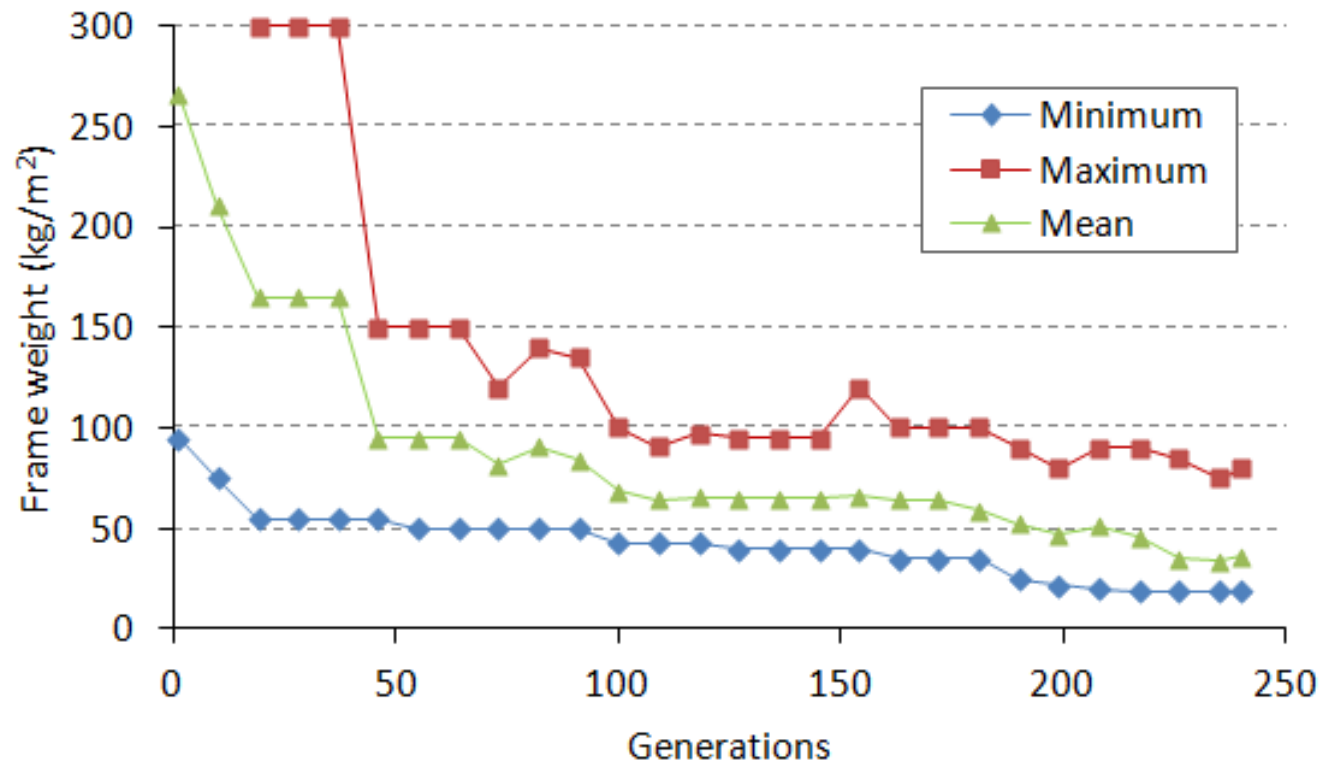
Point mutation:



$$y_i^{(1,t+1)} = x_i^{(1,t+1)} + (x_i^u - x_i^l)\bar{\delta}$$

Engineering Optimization, 45, 2013, 415-33.

Flowchart and convergence



Twenty-First International Specialty Conference on Cold-Formed Steel Structures, 2012, 485-97.

Topography optimisation

1: Geometries and section sizes for three exemplar frames 10°, 4 m

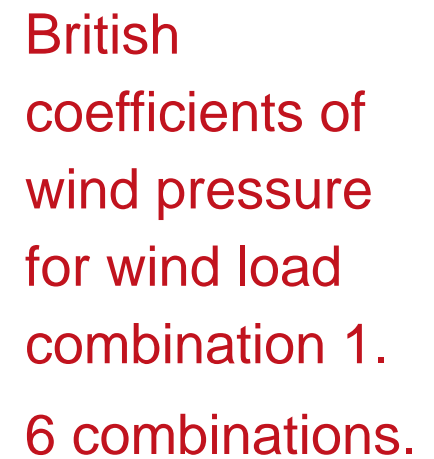


Frame	Span (m)	Height (m)	Section sizes for unit weight (kg/m)			Section sizes for unit cost (AUD/m)		
			Column section	Rafter section	Unit weight	Column section	Rafter section	Unit cost
A	15	3	BBC30030	BBC30030	135.46	BBC30030	BBC30030	384.82
B	20	4	BBC30030	BBC30030	180.60	BBC30030	BBC30030	513.34
C	25	5	BBC35030	BBC35030	269.46	BBC35030	BBC35030	791.60

2: The result of optimum solutions for three exemplar frames

Frame	Span (m)	Height (m)	Pitch (degree)	Bay spacing (m)	Wind pressure (kN/m ²)	Column sections	Rafter sections	Unit cost (AUD/m)
A	15	3	21	3.17	1.45	BBC25024	BBC25024	248.19
B	20	4	21	2.95	0.91	BBC25024	BBC25024	355.60
C	25	5	20.9	2.16	0.68	BBC25024	BBC25024	606.80

Procedia Engineering, 14, 2011, 724-33.



Steel and Composite Structures, **15**, 2013, 519-38.

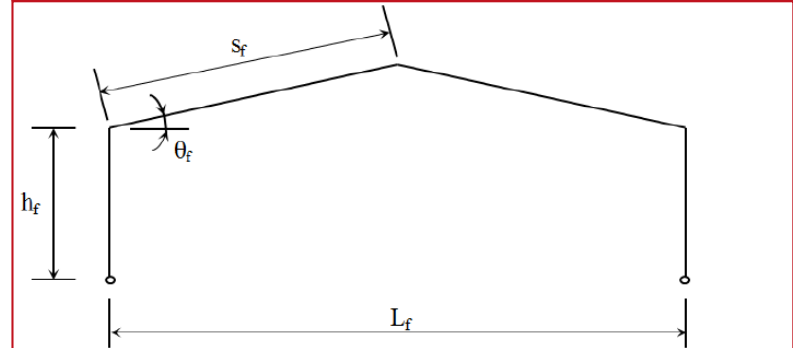
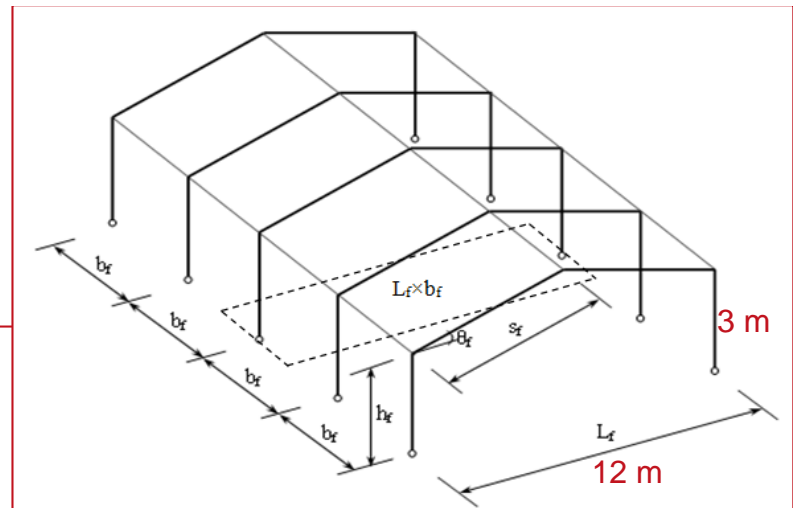
Cost

Hot or cold?

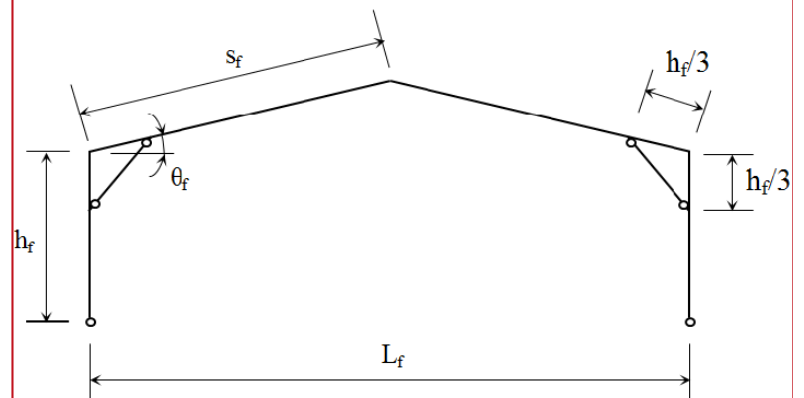
Table 9 Cost of Reference Frame

Type	Topology	Main frame (£/m ²)
Hot-rolled steel	Fixed	6.60
Type 1	Fixed	6.59
Type 1	Variable	5.60
Type 2	Fixed	6.20
Type 2	Variable	4.70

Thin-Walled Structures, under review.



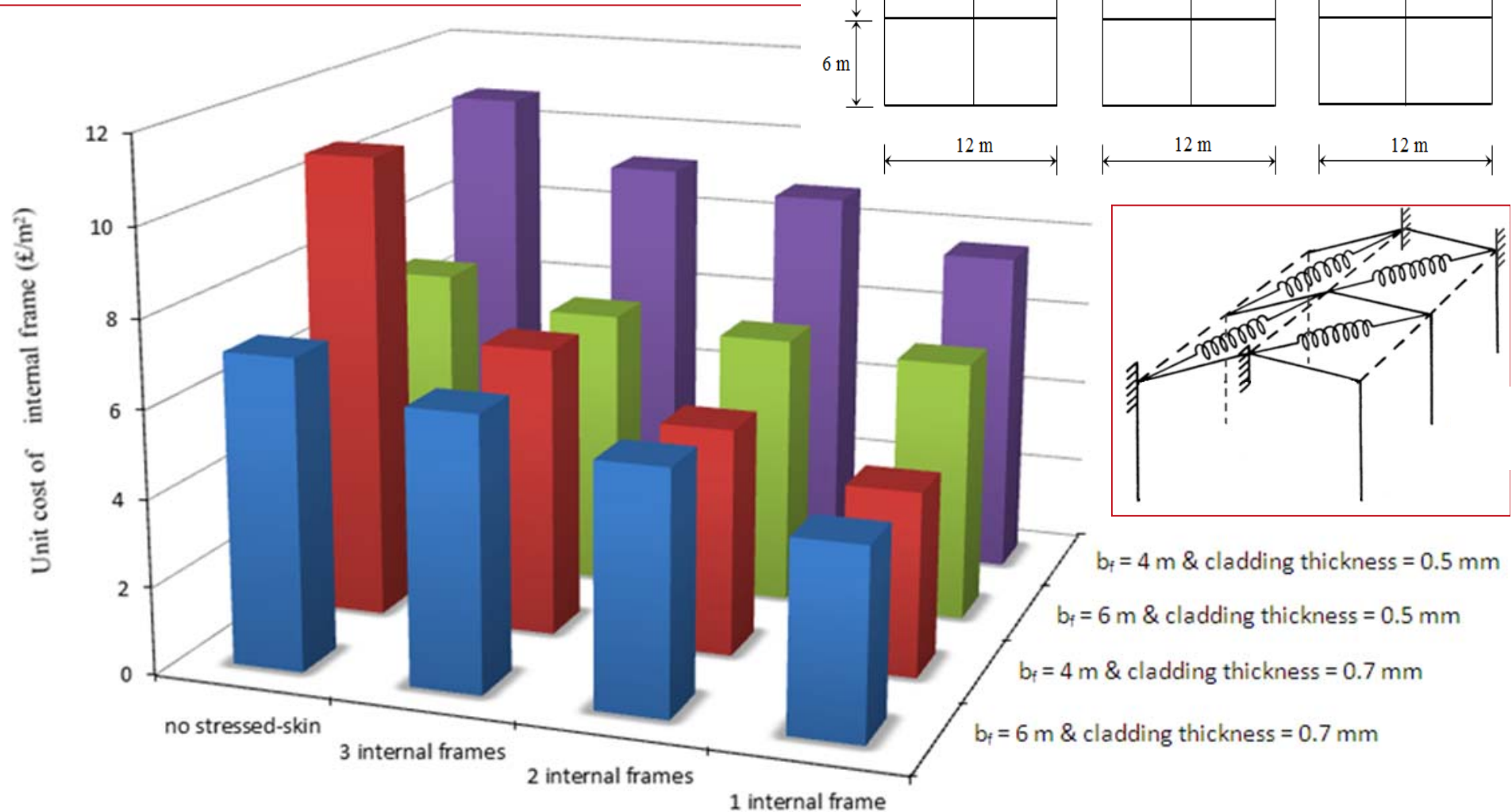
(a) Type 1: Rigid-jointed frame



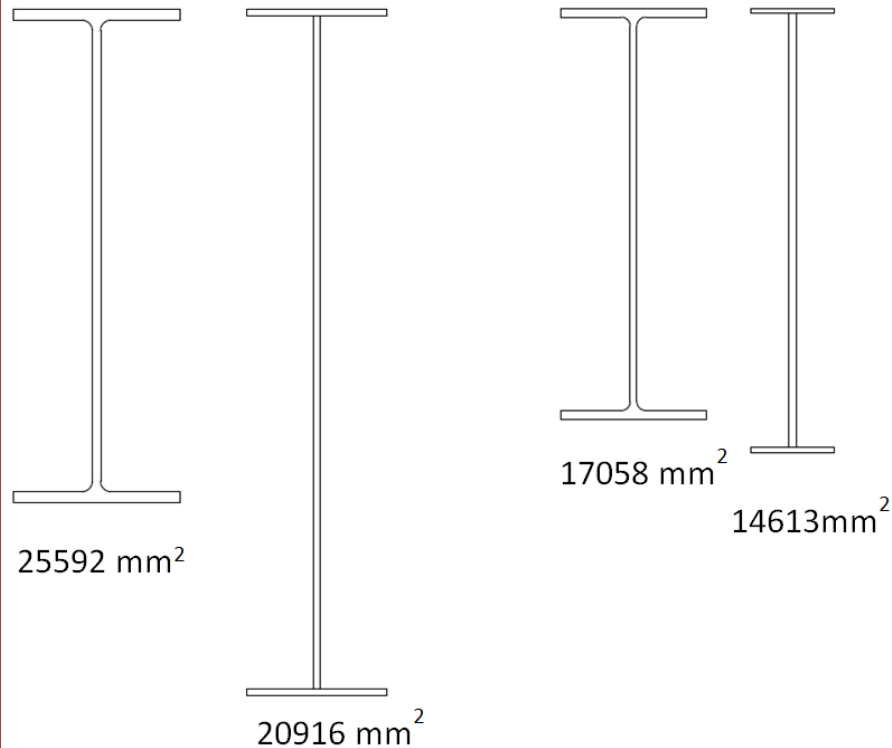
(b) Type 2: Rigid-jointed frame having knee braces at the eaves

Stressed-skin

Cost of internal frames



Optimal design of long-span steel portal frames using fabricated beams to Eurocode 3



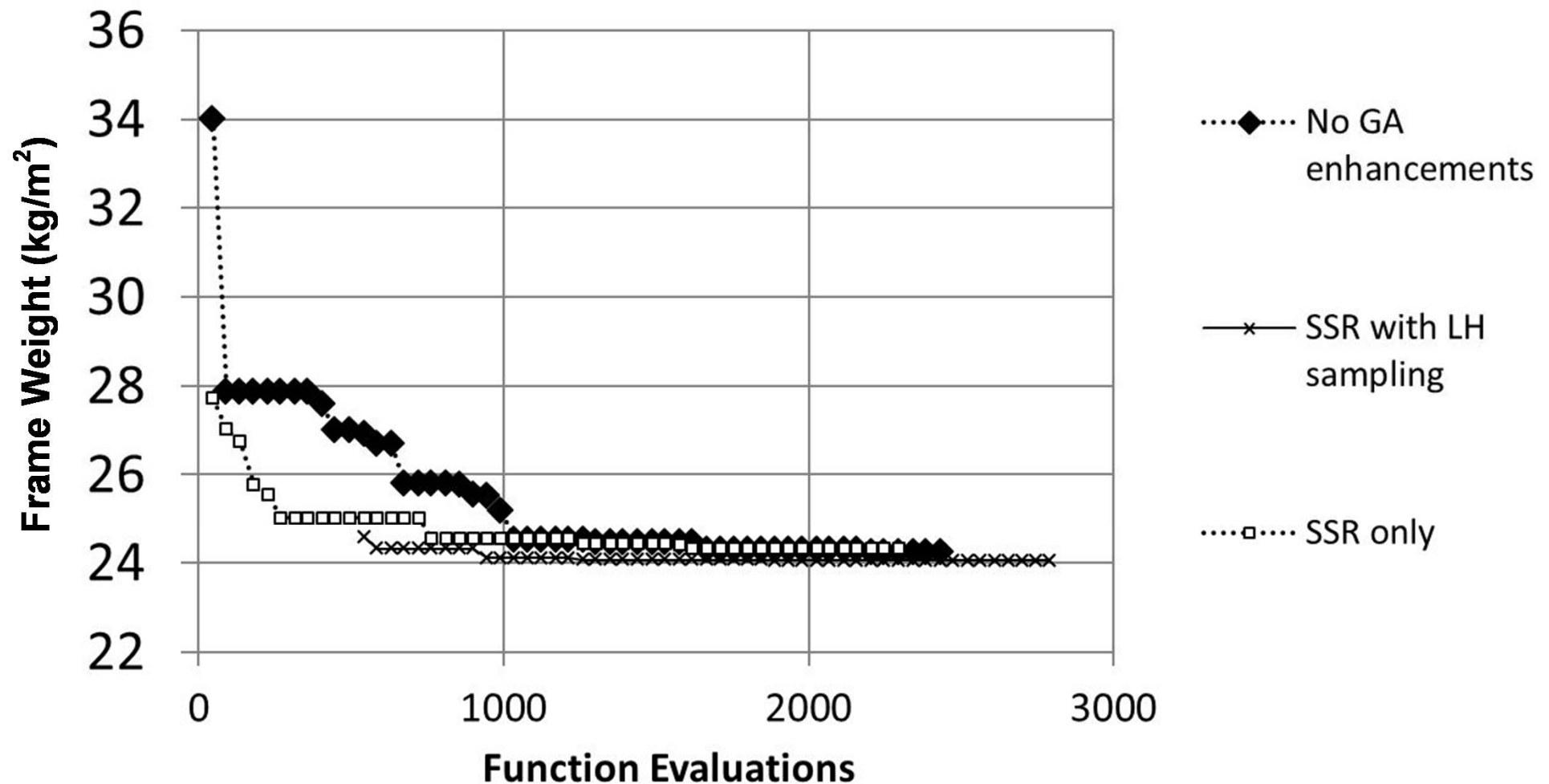
Column

Rafter



35% saving

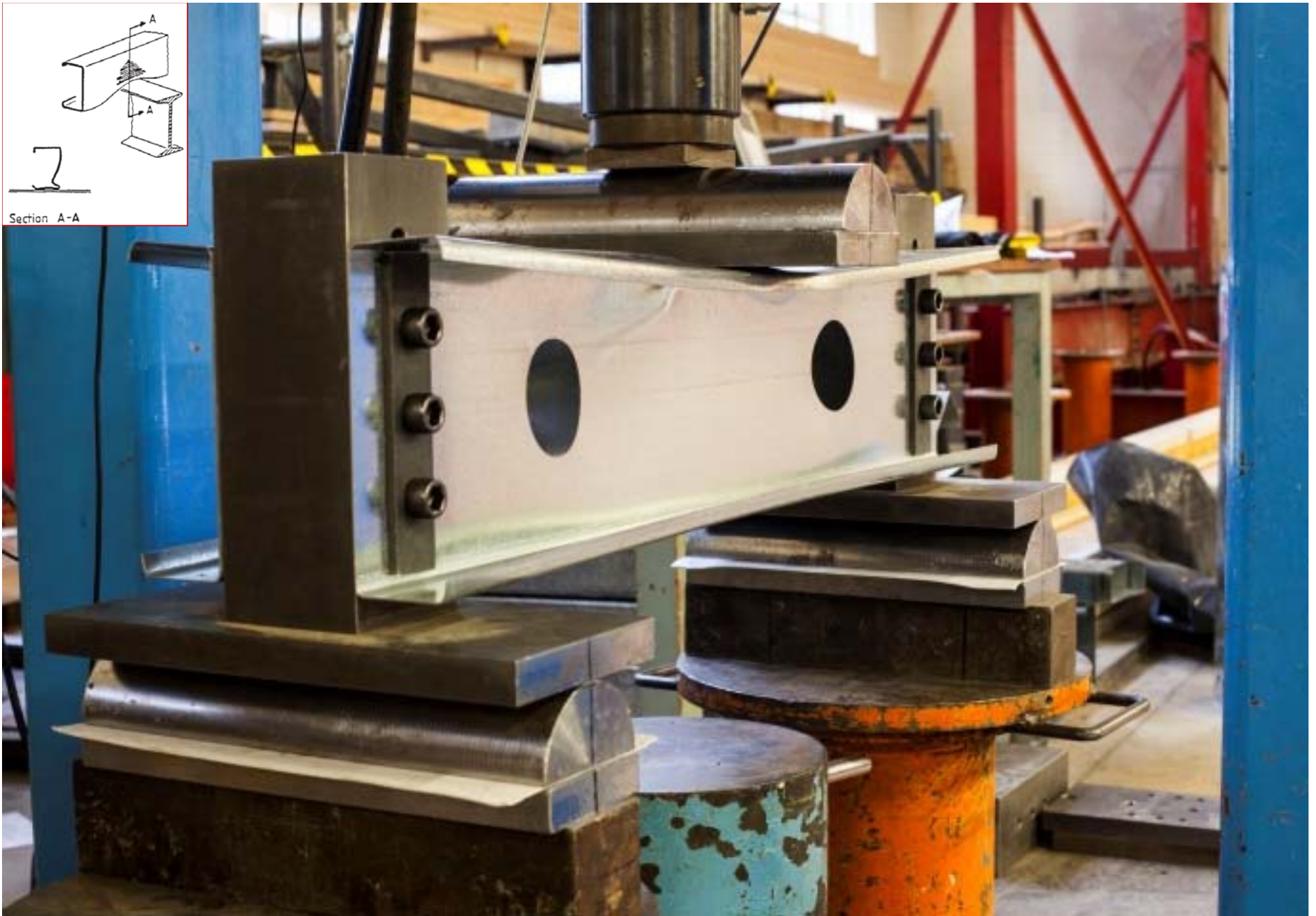
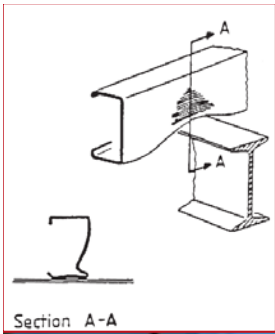
Journal of Constructional Steel Research, under review.



Search space reduction (SSR): eliminating sections with significantly lower moment capacities. Reduced from 80 to 30.

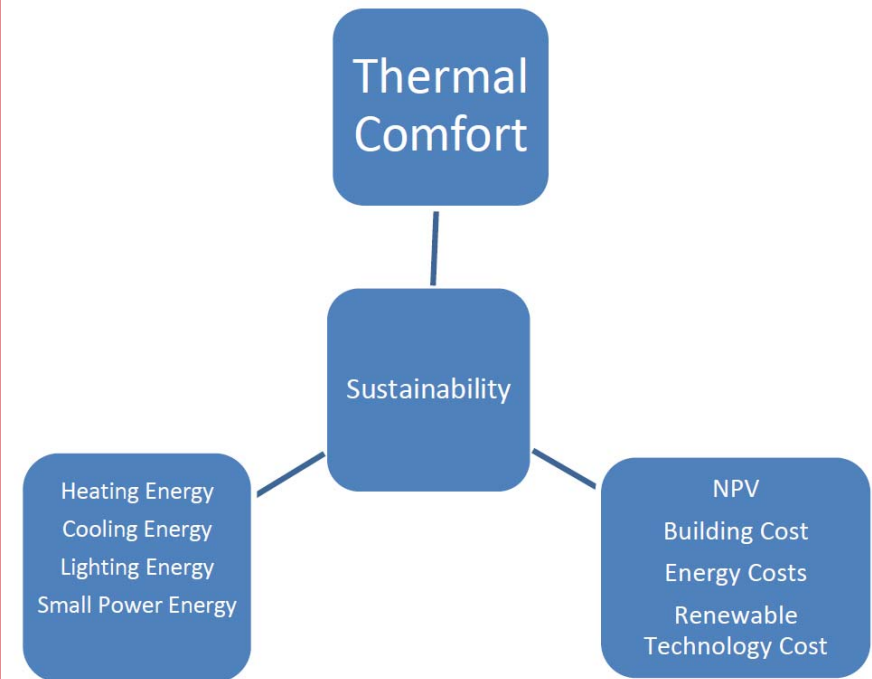
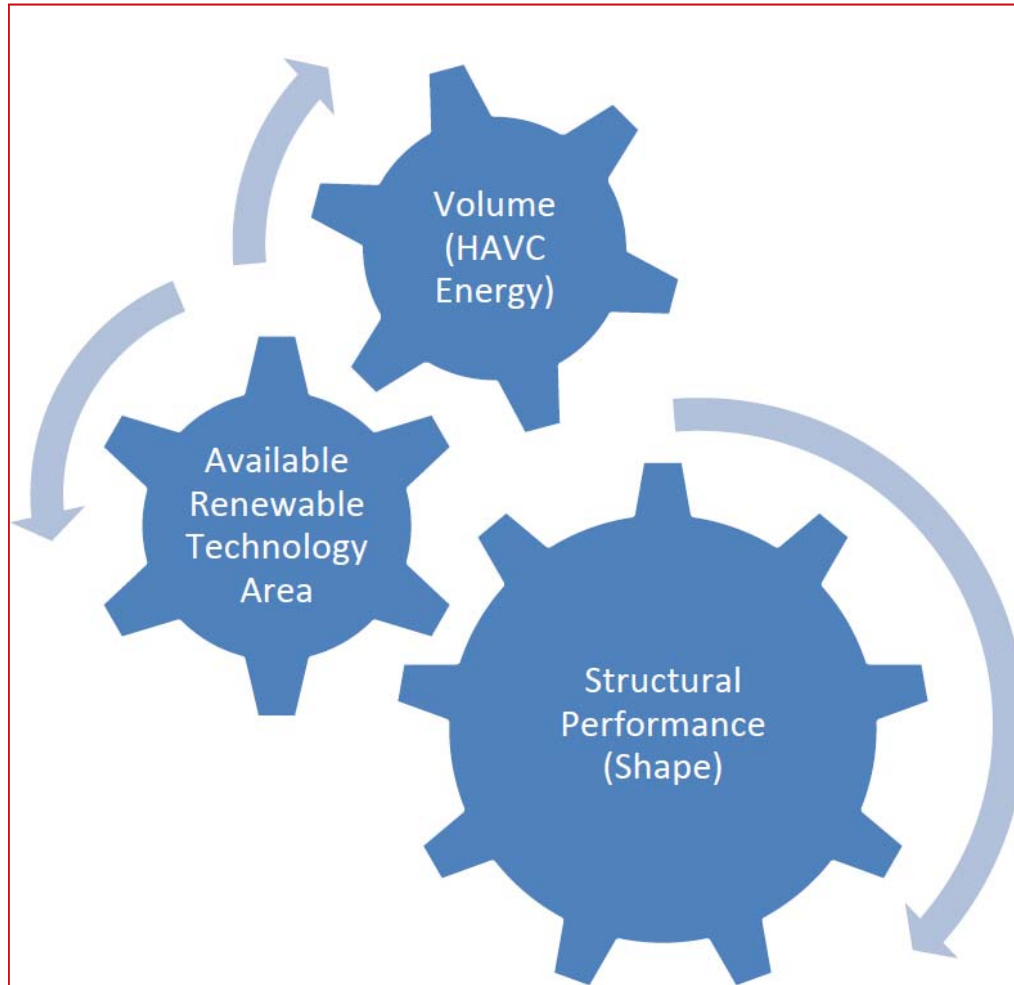
Latin hypercube (LH) sampling plan: larger initial population was ranked based on fitness value.

Journal of Constructional Steel Research, under review.



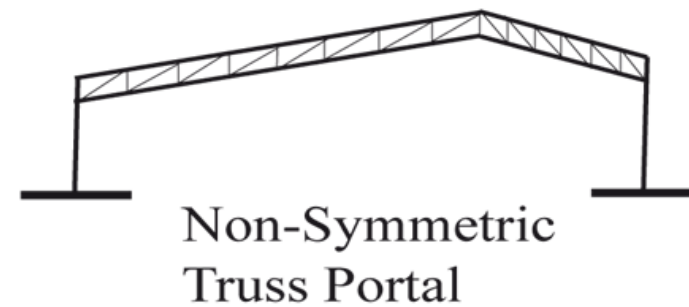
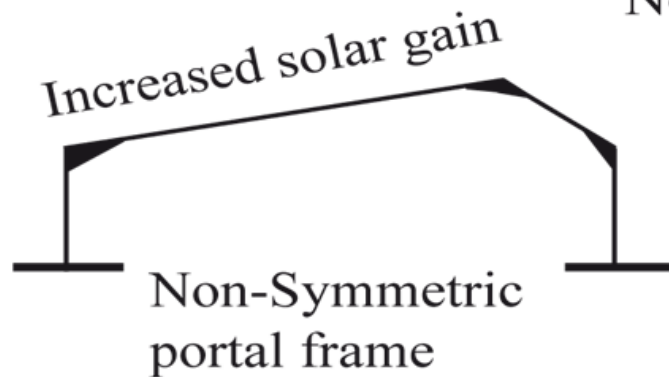
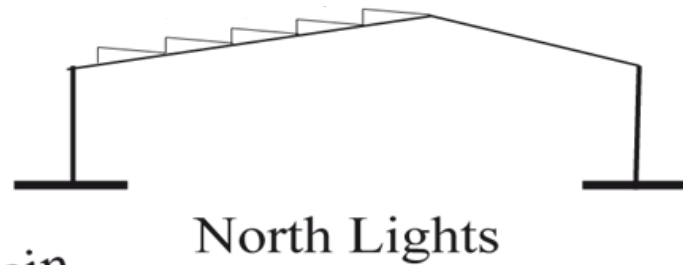
PhD student: Ying Lian

Potential GA objectives



PhD student: Ross McKinstry. KTP with Ostick+Williams

Design options



PhD student: Ross McKinstry

Wei Sha

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